REMARKS

Reexamination and reconsideration of this application as amended is requested. Claims 1, 12, 18, and 29 have been amended. After this amendment, Claims 1-29 remain pending in this application. Applicant submits that the present response places the application in condition for allowance. Entry of the present response is therefore respectfully requested.

Claim Rejections - 35 USC § 101

The Examiner rejected Claim 29 under 35 U.S.C. § 101 stating that Claim 29 is directed towards non-statutory subject matter. In particulat the Examiner stated that "claim 29 dicusses recovering depth information in the preamble of the claim as the main purpose of the method, but does not specifically connect depth information to a tangible concrete result". The Applicant has amended Claim 29 to further recite:

A method of recovering depth information for pixels of a base image representing a view of a scene, the method comprising the steps of:

capturing a base image representing a view of a scene;

tracing at least one parameter surface associated with the base image, each of the at least one parameter surface traced starting from at least one predetermined seed pixel point associated with the base image; and

calculating a derivative of function $E(g)$ with respect to parameter g by using finite difference to minimize the following equation

$$E(g) = \sum_{i=1}^{m} \left\{ 1 - \underset{\omega}{\mathrm{NCC}}\left[I_i(\bar{u}(g), \bar{v}(g)), I_0(u_j, v_j) \right] \right\},$$

where $\underset{\omega}{\mathrm{NCC}}\left[I_i(\bar{u}, \bar{v}), I_0(u_j, v_j) \right]$ is a normalized cross-correlation between $I_i(\bar{u}, \bar{v})$ and $I_0(u_j, v_j)$;

$I_i(\bar{u}, \bar{v})$ is a first window of size $\omega \times \omega$ centered at pixel $(\bar{u}, \bar{v})$ in I_i,

$I_0(u_j, v_j)$ is a second window of size $\omega \times \omega$ centered at pixel (u_j, v_j) in I_0,

I_i is a reference image,
I_0 is a base image.
$(\overline{u}, \overline{v})$ is a pixel point closest to $P_i(C_0+gL(u_j, v_j))$;
$C_0+gL(u_j, v_j)$ is a 3-D point that projects to (u_j, v_j) in the base view, and to $P_i(C_0+gL(u_j, v_j))$ in the i^{th} reference view;
C_0 is the base image camera's center of projection;
$L(u_j,v_j)$ is the unit vector from C_0 to the point on the image plane that corresponds the pixel (u_j,v_j); ~~and~~
g is a depth parameter[[.]]; and
storing the calculated derivative of the function $E(g)$ in a memory.

The Applicant respectfully submits that Claim 29 as amended produces a "useful, concrete and tangile result". Therefore, the Applicant suggests that the rejection of Claim 29 under 35 U.S.C. § 101 has been overcome and the rejection should be withdrawn.

Claim Rejections - 35 USC § 103

The Examiner rejected Claims 1, 4-9, 12-18, and 21-28 under 35 U.S.C. 102(b) as being unpatentable over by Chen and Medioni, "A Volumetric Stereo Matching Method: Application to Image-Based Modeling"' IEEE 19999 and U.S. Patent No. 5,853,672 to Lu.

Applicant has amended independent Claims 1, 12, and 18 to more clearly and distinctly recite the present invention. Applicant has amended Claims 1, 12 and 18 to more clearly recite

"detecting a plurality of pixels in a base image that represents a first view of a scene, wherein the first view is one of at least three relative views of a scene;

determining 3-D depth of the plurality of pixels in the base image by matching correspondence to a plurality of pixels in three or more relative images, representing the at least three relative views of the scene, wherein the three or more images are captured relative to each other and are of the same scene, and wherein the at least three relative views of the scene are situated in a non-linear arrangement relative to each other and are further oriented in non-parallel planes relative to each other; and

tracing pixels in a virtual piecewise continuous depth surface by spatial propagation starting from the detected pixels in the base image by using the matching and corresponding plurality of pixels in the three or more relative images to create the virtual piecewise continuous depth surface viewed from the

base image, each successfully traced pixel being associated with a depth in the scene viewed from the base image."

Support for these amendments may be found in the specification as originally filed, see for example page 22, lines 1-22, page 23, lines 1-21, and page 24, lines 1-2. No new matter was added.

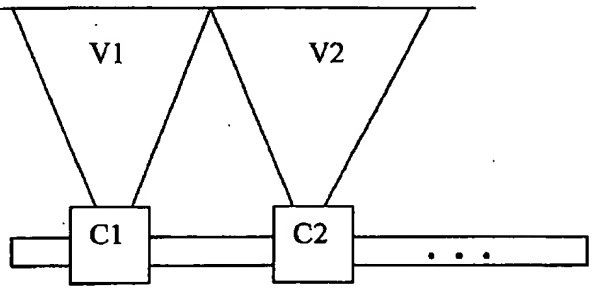
The Examiner directs Applicant to example 4 on page 34 in Chen [VSMM99] where 6 views of a tea pot are used. The Examiner states that Chen [VSMM99] teaches "detecting a plurality of pixels in a base image that represents a first view of a scene wherein the first view is one of at least three views of a scene (e.g. capturing images from various viewpoints of the scene)". However, Chen [VSMM99] only teaches stereo images, that is, Chen [VSMM99] only teaches capturing two images at a time. The Examiner even recognizes this fact on page 5 of the present Office Action ("It should be apparent from the stereo images shown in [Chen, VSMM99]..."). The Examiner also states that Chen [VSMM99] teaches "determining 3-D depth of the plurality of pixels in the base image by matching correspondence to a plurality of pixels in three or more images each image representing one of the at least three views of the scene". However, as discussed in the previous response with amendment, Chen only teaches capturing two images at a time and matching two images at a time. See Chen [VSMM99] generally and at section 3.2 "Disparity surface extraction".

The present invention, on the other hand, now more clearly recites that "...the first view is one of at least three relative views of a scene; determining 3-D depth of the plurality of pixels in the base image by matching correspondence to a plurality of pixels in three or more relative images representing the at least three relative views of the scene, wherein the three or more images are captured relative to each other and are of the same scene..." In other words, each of the three views is relative to one another, e.g., they all include at least an overlapping portion of the scene relative to each other. Using multiple cameras (more than two) arranged in multiple baselines is advantageous over binocular stereo methods as taught by Chen [VSMM99] (and Lu). For example, matching ambiguity is decreased and reconstruction precision is increased.

As stated in the previous response with amendment Chen only teaches using two cameras to capture two images and processing these images two at a time. Therefore, Chen [VSMM99] matches correspondence between pixels of two images at a time and then obtains a result. In Section 3.2.1 of Chen [VSMM99] entitled "Algorithm description", Chen [VSMM99] states "the output from our matching algorithm is a disparity map which corresponds to the voxels that comprise the disparity surface. This is where it differentiates itself from volume rendering, or other matching methods that model the disparity surface as a continuous function". Chen [VSMM99] is comparing disparity surfaces, in other words, Chen [VSMM99] compares the disparity between two surfaces at a time. The (u,v,d) space is working with only two images at a time. The present invention, on the other hand, matches correspondence between all of the images captured relative to each other, which and are of the same scene, for example, three or more relative images, and obtains a result. See for example, page 14, line 14 of the Specification as originally filed. Therefore, the present invention distinguishes over Chen [VSMM99] for at least these reasons.

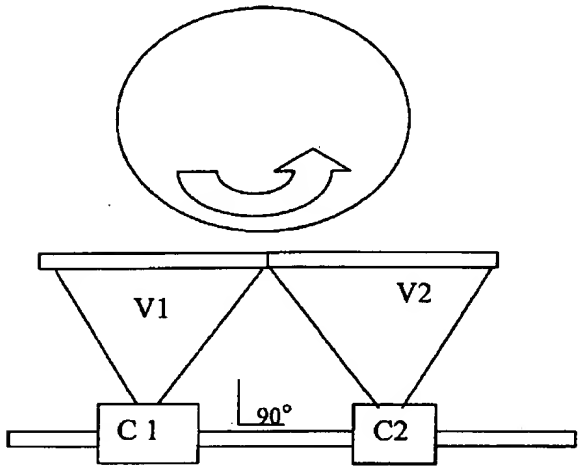
The Examiner also states that Chen [VSMM99] teaches "wherein each of the at least three views of the scene are situated in a non-linear arrangement and are further oriented in a plurality of non-parallel planes relative to each other". The Examiner directs the Applicant to example 4 on page 34 of Chen [VSMM99] where 6 views of a teapot are used. The Examiner states that "Chen discloses using views of a teapot as it is rotated, the views of which would therefore not lie on parallel planes". However, the Applicant respectfully disagrees that Chen [VSMM99] teaches that "each of the at least three views of the scene are situated in a non-linear arrangement" and are "oriented in non-parallel planes relative to each other". The figures below are given to further show the differences between the presently claimed invention and Chen [VSMM99].

Example 1



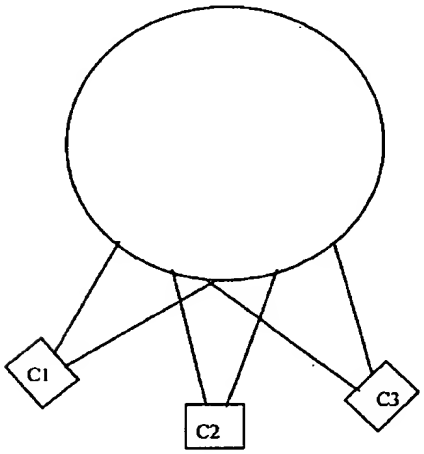
Co-Linear

Example 2



base line

Example 3



The Applicants respectfully point out to the Examiner that Chen [VS99MM] clearly teaches that the views of the scene are situated in a co-linear arrangement. As discussed above, Chen [VSMM99] teaches stereo images, which by definition uses two cameras. As shown in Example 1 and Example 2 above, and in FIG. 1 of the specification as originally filed, a straight line exists between two points. Even though the object in Chen [VSMM99] can rotate, the cameras and the views captured by the cameras remain co-linear, as shown by Example 2. Therefore, because Chen [VSMM99] only teaches using two cameras, Chen [VSMM99] teaches that the views of the scene are situated in a co-linear arrangement. On the other hand, the presently claimed invention recites "the at least three relative views of the scene are situated in a non-linear arrangement relative to each other and are further oriented in non-parallel planes relative to each other" as shown in Example 3 above and FIG. 3 of the specification as originally filed. As can be seen from Example 3, each of the three (not limited to three) cameras captures a view that is relative to a view of another of the three cameras. Accordingly, the present invention distinguishes over Chen [VSMM99] for at least these reasons as well.

Furthermore, the presently claimed invention and Chen [VSMM99] are working in two different spaces. The present invention, as recited for claims 1, 12, 18, is working in a multiple image volume space and Chen [VSMM99] is working in a two-image disparity space. Chen [VSMM99] specifically states that it is not performing volume rendering. Disparity space cannot be used when working when matching three or more relative images simultaneously. Where the Examiner points to in section 3.2 of Chen [VSMM99] is directed towards two images only. Accordingly, the present invention distinguishes over Chen [VSMM99] for at least these reasons as well.

The Examiner correctly states that Chen [VSMM99] "does not explicitly disclose wherein the three images are captured simultaneously". However, the Examiner goes on to combine Chen [VSMM99] with Lu to overcome the deficiencies of Chen [VSMM99]. Lu is directed towards three-dimensional imaging for moving objects. The Examiner directs the

Applicant to col. 3, lines 56-64 and col. 6, lines 1-10 of Lu. However, these citations of Lu merely state that a plurality of images are simultaneously captured from various cameras.

Lu explicitly teaches a three-dimensional motion camera system that comprises one or more imaging heads. For example, Lu teaches that three imaging heads surround an object of interest every 120 degrees. See FIG. 1 of Lu. Each imaging head includes a light projector that is placed in between two video cameras. See col. 3, lines 39-47. The light projector is used to project line strips onto the object of interest. Lu explicitly teaches that the two cameras in an imaging head are separated by a base line and are calibrated with respect to a fixed relative position and focus. See col. 3, lines 45-47 and lines 66-67. Therefore, the cameras in an imaging head are co-linear and the present invention distinguishes over Lu for at least this reason.

Furthermore, Lu (like Chen [VSMM99] only teaches matching two images at a time. For example, each imaging head of Lu captures two images and even though up to six images can be captured at once, only the two separate images from each imaging head are matched with each other. Lu teaches "each of the sets of stereo pair of images is processed by the computer to generate three dimensional coordinates of the object surface at the grid points. The processing software mainly establishes correspondence of grid points "seen" from two perspectives (cameras). A surface can then be reconstructed from individual imaging head that are "pasted" together based using the virtual-world coordinate system". See Lu at col. 3, lines 58-65. This clearly shows that even though Lu may capture multiple views at the same time, Lu only performs matching between the two images of an imaging head. Furthermore, nowhere does Lu teach or suggest capturing three or more relative images simultaneously. In other words, nowhere does Lu teach three or more cameras capturing relative views (e.g., views that have at least an overlapping portion). Therefore Lu does not teach or suggest "determining 3-D depth of the plurality of pixels in the base image by matching correspondence to a plurality of pixels in three or more relative images representing the at least relative three views of the scene, wherein the three or more images are captured relative to each other and are of the same scene, and wherein each of the at least three relative views of the scene are situated in a non-linear

arrangement relative to each other and are further oriented in a plurality of non-parallel planes relative to each other; and tracing pixels in a virtual piecewise continuous depth surface by spatial propagation starting from the detected pixels in the base image by using the matching and corresponding plurality of pixels in the three or more relative images to create the virtual piecewise continuous depth surface viewed from the base image, each successfully traced pixel being associated with a depth in the scene viewed from the base image".

Accordingly, the presently claimed invention distinguishes over Lu for at least these reasons as well.

Moreover, the Federal Circuit has consistently held that when a §103 rejection is based upon a modification of a reference that destroys the intent, purpose or function of the invention disclosed in the reference, such a proposed modification is not proper and the *prima facie* case of obviousness cannot be properly made. See In re Gordon, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984).

Here the intent, purpose, and function of Chen [VSMM9] taken alone or in view of Lu is a system for volumetric stereo matching. The Examiner asserts on page 6 of the present Office Action that Chen [VSMM99] teaches that views are not on parallel planes. Assuming arguendo that the Examiner is correct, because Lu teaches that the views are parallel (See, for example, LU at FIG. 2, FIG. 9, and FIG. 12), this combination as suggested by the Examiner destroys the intent and purpose of Chen's {VSMM99] alleged intent of having views on non-parallel planes. In contrast, the intent of the present invention, among other things, is to have "...the at least three relative views of the scene are situated in a non-linear arrangement relative to each other and are further oriented in non-parallel planes relative to each other". As discussed above, Chen [VSMM99] and Lu both teach stereo views and only matching two views. Stereo views by definition are co-linear. Accordingly, since the Examiner characterizes Chen [VSMM99] as teaching views not on parallel planes and since Lu teaches that views are parallel to each other, the combination of Chen [VSMM99] and Lu results in an inoperable system. Therefore, the Examiner's case of *"Prima Facie Obviousness"* should be withdrawn.

Furthermore, the Federal Circuit stated in McGinley v. Franklin Sports, Inc., (Fed Cir 2001) that if references taken in combination would produce a "seemingly inoperative device," such references teach away from the combination and thus cannot serve as predicates for a prima facie case of obviousness. In re Sponnoble, 405 F.2d 578, 587, 160 USPQ 237, 244 (CCPA 1969) (references teach away from combination if combination produces seemingly inoperative device); see also In re Gordon, 733 F.2d 900, 902, 221 USPQ 1125, 1127 (Fed. Cir. 1984) (inoperable modification teaches away). As discussed above, the Examiner asserts that the views in Chen [VSMM99] are in non-parallel planes. However, Lu teaches that the views are parallel (See, for example, LU at FIG. 2, FIG. 9, and FIG. 12) Therefore, the combination of Chen [VSMM99] with Lu to produce the presently claimed invention where "...the at least three relative views of the scene are situated in a non-linear arrangement relative to each other and are further oriented in non-parallel planes relative to each other", would produce an inoperable device. Accordingly, the combination of Chen [VSMM99] and Lu is improper.

Further, when there is no suggestion or teaching in the prior art for "detecting a plurality of pixels in a base image that represents a first view of a scene, wherein the first view is one of at least three relative views of a scene; determining 3-D depth of the plurality of pixels in the base image by matching correspondence to a plurality of pixels in three or more relative images representing the at least three relative views of the scene, wherein the three or more images are captured relative to each other and are of the same scene, and wherein the at least three relative views of the scene are situated in a non-linear arrangement relative to each other and are further oriented in non-parallel planes relative to each other; and tracing pixels in a virtual piecewise continuous depth surface by spatial propagation starting from the detected pixels in the base image by using the matching and corresponding plurality of pixels in the three or more relative images to create the virtual piecewise continuous depth surface viewed from the base image, each successfully traced pixel being associated with a depth in the scene viewed from the base image", the suggestion can not come from the Applicants' own specification. The Federal Circuit has repeatedly warned against using the Applicant's disclosure as a blueprint to reconstruct the claimed invention out of isolated teachings of the prior art. See MPEP §2143 and

Grain Processing Corp. v. American Maize-Products, 840 F.2d 902, 907, 5 USPQ2d 1788 1792 (Fed. Cir. 1988) and In re Fitch, 972 F.2d 160, 12 USPQ2d 1780, 1783-84 (Fed. Cir. 1992).

For the foregoing reasons, Claims 1, 12, and 18 distinguish over Chen [VSMM9] in view of Lu. Claims 4-9, 13-17, and 21-28 depend from Claims 1, 12, and 18, respectively, and since dependent claims contain all the limitations of the independent claims, Claims 4-9, 13-17, and 21-26 distinguish over Chen [VSMM9] alone or in combination with Lu, as well. Accordingly, Applicant believes that the rejection under 35 U.S.C. § 103(a) has been overcome and respectfully requests that this rejection be withdrawn.

Additionally, neither single reference nor a combination therefore teaches or suggest the presently claimed invention.

The Examiner rejected Claims 27-28 under 35 U.S.C. 103(a) as being unpatentable over Chen and Medioni, "A Volumetric Stereo Matching Method: Application to Image-Based Modeling"' IEEE 19999.

Claims 27-28 depend from amended Claim 18. The above arguments and remarks regarding Claim 18 are likewise applicable here in support of the allowability of Claims 27-28. These applicable arguments have already been presented above and will not be repeated here. Therefore, Applicant believes that the rejection of Claims 27-28 has been overcome and requests that the rejection be withdrawn.

The Examiner rejected Claims 2-3 and 19-20 under 35 U.S.C. 103(a) as being unpatentable over Chen and Medioni, "A Volumetric Stereo Matching Method: Application to Image-Based Modeling"' IEEE 1999 and U.S. Patent No. 5,852,672 to Lu, in view of Zhang, Deriche, Faugeras, and Luong, "A Robust Technique for Matching Two Uncalibrated Images Through the Recovery of Unknown Epipolar Geometry", INRIA 1994).

Claims 2-3 and 19-20 depend from amended Claims 1 and 18, respectively. The above arguments and remarks regarding Claims 1 and 18 are likewise applicable here in support of the allowability of Claims 2-3 and 19-20. These applicable arguments have already been presented above and will not be repeated here.

The Applicant repeats here the arguments made in the previous two responses with amendments regarding Zhang. Zhang teaches a robust technique for matching two uncalibrated images through the recovery of the unknown epipolar geometry. The Examiner has directed Applicant to Section 6.3 on pages 16-19 of Zhang, wherein Zhang teaches a stereo matching method. Additionally, Zhang teaches that outliers will severely affect the precision of the fundamental Matrix taught by Zhang. Therefore, possible outliers should be taken into account in the initial correspondences. However, Zhang does not teach or suggest "...determining 3-D depth of the plurality of pixels in the base image by matching correspondence to a plurality of pixels in three or more relative images representing the at least three relative views of the scene, wherein the three or more images are captured relative to each other and are of the same scene, ...", nor does the reference teach or suggest that each image represents one of the at least three relative views of the scene that are situated in a non-linear arrangement and are further oriented in non-parallel planes relative to each other. See for example FIG. 1. Further, Zhang does not teach or suggest "tracing pixels in a virtual piecewise continuous depth surface by spatial propagation starting from the detected pixels in the base image by using the matching and corresponding plurality of pixels in the three or more relative images to create the virtual piecewise continuous depth surface viewed from the base image, each successfully traced pixel being associated with a depth in the scene viewed from the base image" as presently claimed in Claims 1 and 18. Therefore, Zhang does not teach or suggest the presently claimed invention as recited for amended independent Claims 1 and 18 from which dependent Claims 2-3 and 19-20 depend from, respectively.

Accordingly, in view of the amendments and remarks above, since Chen [VSMM99], Lu, or Zhang either taken singly or in any combination thereof does not teach, anticipate, or suggest, the presently claimed "...determining 3-D depth of the plurality of pixels in the base image by

matching correspondence to a plurality of pixels in three or more relative images representing the at least three relative views of the scene, wherein the three or more images are captured relative to each other and are of the same scene, and wherein the at least three relative views of the scene are situated in a non-linear arrangement relative to each other and are further oriented in non-parallel planes relative to each other; and tracing pixels in a virtual piecewise continuous depth surface by spatial propagation starting from the detected pixels in the base image by using the matching and corresponding plurality of pixels in the three or more relative images to create the virtual piecewise continuous depth surface viewed from the base image, each successfully traced pixel being associated with a depth in the scene viewed from the base image" as recited for amended Claims 1 and 18 from which Claims 2-3 and 19-20 respectively depend from, Applicant believes that the rejection of Claims 2-3 and 19-20 under 35 U.S.C. 103(a) has been overcome. The Examiner should withdraw the rejection of these claims.

The Examiner rejected Claims 10-11 under 35 U.S.C. 103(a) as being unpatentable over Chen and Medioni, "A Volumetric Stereo Matching Method: Application to Image-Based Modeling"' IEEE 1999 and U.S. Patent No. 5,852,672 to Lu, in view of Okutomi and Kanade, "A Multiple-Baseline Stereo", IEEE 1993 in further view of Lewis, "Fast normalized Cross-Correlation", 1995.

Claims 10-11 depend from amended Claim 1. The above arguments and remarks regarding Claim 1 are likewise applicable here in support of the allowability of Claims 10-11. These applicable arguments have already been presented above and will not be repeated here.

As has already been previously discussed in Applicant's two previous responses, Okutomi teaches a stereo matching method that uses multiple stereo pairs with various baselines to obtain precise distance estimates without suffering from ambiguity. Okutomi teaches that the summation of the sum of squared differences (SSD) from multiple stereo pairs can be used to indicate the "correctness" of a set of matching points. However, Okutomi clearly does not teach or suggest the presently claimed invention as recited for amended independent Claim 1, and for dependent Claims 10-11.

As has already been previously discussed in the previous two responses Lewis teaches how un-normalized cross correlation can be efficiently normalized using precomputing integrals of the image and image^2 over the search window. However, it should be clear that Lewis does not teach or suggest the presently claimed invention as recited for amended independent Claim 1, and for dependent Claims 10-11.

Accordingly, in view of the amendments and remarks above, since the teachings of Chen [VSMM99], Lu, Okutomi, and Lewis, either taken singly or in any combination thereof do not teach, anticipate, or suggest, the presently claimed "...determining 3-D depth of the plurality of pixels in the base image by matching correspondence to a plurality of pixels in three or more relative images representing the at least three relative views of the scene, wherein the three or more images are captured relative to each other and are of the same scene, and wherein the at least three relative views of the scene are situated in a non-linear arrangement relative to each other and are further oriented in non-parallel planes relative to each other; and tracing pixels in a virtual piecewise continuous depth surface by spatial propagation starting from the detected pixels in the base image by using the matching and corresponding plurality of pixels in the three or more relative images to create the virtual piecewise continuous depth surface viewed from the base image, each successfully traced pixel being associated with a depth in the scene viewed from the base image", as recited for amended Claims 1 from which Claims 10-11 respectively depend from, Applicant believes that the rejection of Claims 10-11 under 35 U.S.C. 103(a) has been overcome. The Examiner should withdraw the rejection of these claims.

Conclusion

The foregoing is submitted as full and complete response to the Official Action mailed April 19, 2006, and it is submitted that Claims 1-29 are in condition for allowance or are at least presented in better form for appeal. Reconsideration of the rejection is requested. Allowance of Claims 1-29 is earnestly solicited.

No amendment made was related to the statutory requirements of patentability unless expressly stated herein. No amendment made was for the purpose of narrowing the scope of any claim, unless Applicant has argued herein that such amendment was made to distinguish over a particular reference or combination of references.

Applicant acknowledges the continuing duty of candor and good faith to disclose information known to be material to the examination of this application. In accordance with 37 CFR § 1.56, all such information is dutifully made of record. The foreseeable equivalents of any territory surrendered by amendment are limited to the territory taught by the information of record. No other territory afforded by the doctrine of equivalents is knowingly surrendered and everything else is unforeseeable at the time of this amendment by the Applicant and the attorneys.

The present application, after entry of this amendment, comprises twenty-nine (29) claims, including four (4) independent claims. Applicant has previously paid for twenty-nine (29) claims including four (4) independent claims. Applicant, therefore, believes that a fee for claims amendment is currently not due.

If the Examiner believes that there are any informalities that can be corrected by Examiner's amendment, or that in any way it would help expedite the prosecution of the patent application, a telephone call to the undersigned at (561) 989-9811 is respectfully solicited.

The Commissioner is hereby authorized to charge any fees that may be required or credit any overpayment to Deposit Account **50-1556**.

In view of the preceding discussion, it is submitted that the claims are in condition for allowance. Reconsideration and re-examination is requested.

Respectfully submitted,

Date: July 19, 2006 By: _____

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